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ABSTRACT

This address deals with the phenomenon of modern technology in the context of: (1) its potential to alter society, (2) its implications as a discipline base for education, (3) specific curriculum developments necessary with technology as a conceptual frame of reference, (4) its behavioral characteristics in an "environmental continuum" and an "activity continuum" for an interdisciplinary approach to problem solving, (5) a taxonomy for transportation technology, illustrated by means of 11 diagrams, (6) nine steps for program development utilizing a specific discipline in a taxonometric approach, and (7) a future-oriented approach to education as an institution for meeting human needs. This final step for our society will require education to: (1) incorporate the study of the "Behavior of Technological and Social Systems" and (2) provide access to tools which will maximize the ability to pursue the educational system's goals. A bibliography and a diagram of a program development matrix are included. (AG)

EDUCATION
IN A
TECHNOLOGICAL SOCIETY
"ACCESS TO TOOLS"

by
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West Virginia University
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EDUCATION IN A TECHNOLOGICAL SOCIETY
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Introduction: It is reported in a familiar story that a Roman Centurion pushed his way into the presence of Rabbi Hillel and demanded that while he, the soldier, stood on one foot, the sage should sum up the Judaic teachings. Unaffronted and undaunted, Rabbi Hillel replied:

> "What thou wouldst not have done unto thee, do not that to thy neighbor. This is the law. The rest is commentary."

Today one might declare: "The freedom of man and the future of civilization depend on man's ability to understand and control his special power, technology." This is the basic premise. The rest is commentary.

Many of us are aware at least superficially, that civilization has progressed in the last hundred years or so from an agricultural society, to an industrial society, to a technological society. This is what we are told. We are, however, unaware that the change which has taken place in the last hundred years has been more than a change in the outer appearance of our tools. What has happened is that an entirely new phenomenon, unknown before in the history of man, has been created. This phenomenon is Modern Technology. To gain a perspective of this phenomena, let us take a look at the history of man.

> Anthropologists are not able to agree on the date for the first coming of Man on Earth, but the range generally accepted is between a quarter of a million and a million years ago. If the first estimate, 250,000 years, is taken and reduced to the scale of one hour, some sense of the relative time spent by man in the several phases of technical progress can be attained.
>
> Making the scale an even 240,000 for mathematical convenience, man then spent 55 minutes, or 11/12 of the whole period in the paleolithic or old stone age culture.
>
> Five minutes ago he embarked upon the neolithic culture, the cultivation of plants, the domestication of animals, the making of pottery, weaving, and the use of the bow and arrow; 3 1/2 minutes ago he began the working of copper; 2 1/2 minutes ago he began to mold bronze; 2 minutes ago he learned to smelt iron; 1/4 of a minute ago he learned printing; 5 seconds ago the industrial revolution began; 3 1/3 seconds ago he learned to apply electricity; and the time he has had the automobile is less than the intervals between the ticks of a watch, i.e., less than one second. (Wallace, p. 99)

The exponential growth and development of Technology by man has in recent times altered his very existence. Through the rational power of his mind, coupled with his unique biological and physical make-up, man has developed and expanded his technical knowledge. He has created a vast storehouse of techniques. And, as he created these techniques, he changed his way of life. His economy changed. His social life changed. Man himself evolved. His technology provided for a division of labor and a restructuring of society. Man perceived himself differently because of technology. His conception of time, space and distance evolved and changed as his methods of transportation and communication developed and became more sophisticated.

The body of knowledge man created in the development of his technology changed man both intellectually and psychologically. His hopes and fears of the future became tied closely to his creation, technology.

Through his technology man gained power. As he built his technology man learned to deal in ideas and concepts. And as his knowledge and understanding grew he discovered means of dealing with his technological environment and its problems.

Man developed a rationale, a method of solving his problems. Postulation, deductive reasoning, empirical verification, inferences, proof and discovery were found to be methods of dealing with technological concepts.

Through the development of technology man has enhanced his potential for freedom. He has enhanced his potential for mastering his own future. In attaining these potentials man has created in his technologies some of his greatest intellectual achievements, achievements seldom noted as such because of society's great preoccupation with other discipline areas such as music, art, literature and politics. In terms of importance, however, man's technological achievements were and continue to be equal to and in many cases surpass achievements of other disciplines.

When we look at the history of man from a technological point of view we discover there has been five significant and quantitative changes in the history of man which incorporate man's greatest intellectual achievements. They are: (1) the discovery of tools, (2) the discovery that one tool could be used to make another tool (the basis of our modern machine tool industry), (3) the discovery of agriculture and the cultivation of plants, (4) the industrial revolution and (5) the scientific-technological revolution.

It is interesting to note that although there are many ways to view man historically, most all systems of classification relate directly to man's technology in some way. Classifications are based generally on materials such as stone, bronze, or iron or on the nature of man's techniques typified by stages of civilization characterized by phrases such as the stage of: (1) adaptation, (2) domestication, (3) diversification, (4) mechanization and (5) automation.

Each of these stages exists in various levels of sophistication even today. The Western World, however, is typified by Stage 5, automation. Western man has made a transition from individual discrete crafts and trades and an economy of scarcity, through industrialization, automation and cybernation to an economy of abundance. In the process an entirely different technology from that of yesterday has been created.

By way of example, let us consider agriculture. Assume there are 100 acres of land being farmed by 100 men, women and children. These men, women and children work 10 hours per day, 365 days per year to maintain themselves on the 100 acres. If we calculate we find that this economy, utilizing a given level of technology, requires 365,000 man-hours per year to maintain equilibrium, a subsistence economy.

Sometime during this process some men began to utilize their intellect. In doing so they created new agricultural techniques.

With the new techniques man found that the full 100 acres was no longer required to produce the food and fiber for 100 people. Ten acres would produce the same amount as 100 acres. Furthermore, they found it required the effort of only 5 people working 8 hours per day, 5 days a week, 260 days per year, to produce the food and fiber for 100 people. In the process, however, 95 people were disemployed and the other 5 were relieved of much of their work load.

An analysis of the development of technology indicates that social problems of considerable consequence have been created, not the least of which is: "What do people do when their work is no longer needed?" We also discover a basic truth. The purpose of technology is the disemployment of human labor.

Technology and Society: Man, in the process of creating his technology has altered his potential. He has altered his perception of himself, his culture and even his concept of reality. He has done so through the creation and development of technology, a new and powerful force little understood by man.

Man's developing awareness of his technology, as a new and powerful force within his culture, has come about because of wide spread social consequences. Technology has become a powerful disruptive force within society, and rather than being one of many factors within the cultural fabric of society, has emerged as a dominant factor altering the options, choices and potential of man and society. The new choices, alternatives and options resulting from this new phenomena have changed our basic assumptions about man, society and education. We find that modern technology, based on (1) the collection and organization of knowledge, (2) the systematic analysis of knowledge and (3) the publication and wide distribution of knowledge has not only altered the man, society, education equation; it has created an entirely new equation with many new variables, new realities, new alternatives, new choices and new social consequences.

The increasing power of technology and the rapidity of change, combined with an increasing world population, has formed an explosive and disruptive force within society, the consequences of which we are only beginning to imagine. Whereas in earlier times technology was largely an individual matter with individual choices impacting on other individuals within limited environments, today, the consequences of individual decisions and choices, coupled with the power of technology, have created and are creating social and natural disasters. The time to reach a critical mass has been shortened and the reactions have taken on the characteristics of electromagnetic waves with many consequences in different locations at different times.

We have reached that stage in our history where the question has become one of man controlling his technology or of technology controlling man. With our compulsion for utilizing decision making models, based on "crisis," the future does not look too favorable. Crisis decision making procedures may have worked in the past when changes were slower and technology less powerful. Today, however, we are in danger of the mass going critical and self destructing before we can activate the control rods. This assumes, of course, we know enough about the man, society, technology equation to exercise control. It is the premise of this analysis that we do not. We do not comprehend or understand the behavior of the technological systems with which we are dealing. It is also a premise of this analysis that the highest order of life, the most humane existence for the most people will come about through a high order technological society, provided man can comprehend and understand the behavioral characteristics of his technological society and control it. However, it must be remembered that we can control only that which we know about and understand in behavioral terms.

The probabilities of our controlling and using technology for enhancing the humaneness of life and living on the space ship earth are rather remote. This is so because most institutions within society, including education, conceive of technology in a highly restricted sense, primarily as tools and their use. For instance, most school programs offer cources in tool using and material processing based on a conception of technology and society long since passed. One of the better illustrations of the development of technological comprehension which shows the discrepency between education and reality is provided by Skolimowski. Skolimowski describes technology in terms of levels of awareness. Technology can thus be conceived as:

1. The totality of all man-made tools;

- or -

2. The totality of all man-made tools and their function and use;

- or -

3. The totality of all man-made tools, their function and use and the material results of their application (technological products);

- or -

4. The totality of all man-made tools, their function and use, the material results of their application (technological products) and the social impact of these products;

- or -

5. The totality of all man-made tools, their function and use, the material results of their application (technological products), the social impact of these products and the influence of technological change on the life of particular individuals and societies and groups. (Skolimowski p. 35)

In addition, Skolimowski stresses the difference between Technology with a capital T and technologies with a lower case t. The Technology of today cannot be understood by examining the features of particular technologies such as welding technology or vacuum forming technology or the tools associated with these processes. These are the technologies of the lower case t. The whole is a different phenomenon than are the parts.

Because this is the situation, man must develop a new perception, a new mentality, if he is to control his creation for the benefit of all men and not a few men. By implication, this means we must redefine the function of education in our society and that our educational system must be restructured to focus on questions of the <u>behavior and control of technology for man</u>, rather than the question of the behavior and control of man for technology.

A major shift in our value system is required if we are to attain control of Technology for all men. Many educators and others assuming roles of authority do not conceive Technology in the control of the common man. Technology, it seems, has become too important to be trusted to the hands of the common man. But they miss a crucial point so well summarized by Silber.

(1) True freedom is impossible without Technology.

- and -

(2) True Technology is impossible without freedom.

By denying all men a role, and in so doing denying freedom to some, we will effectively destroy and mute the very element, Technology, which provides man with his greatest opportunity for true freedom.

Many people and institutions today focus on the use of Technology for the control of other men rather than the control of Technology for the benefit and self actualization of all men. An attitude has been developed which says that the good life can be attained only when one is in the dominant position. (Landers, p. 224)

The question is not one of control for the purpose of attaining dominance over others, however. The question is one of the control of the behavior of Technological systems for the purpose of attaining equilibrium and balance rather than continual progress, disruption and ultimate destruction of society as we know it and envision it.

The implications for education are considerable. Educators have long considered Technology and things technical as non-intellectual following Plato's separation of ideas from things. Today we discover that the new Technology is knowledge based and that the creation of Technology is and always has been of the mind. Without man and his intellectual powers there would be no Technology. Technology always has been a very human, creative and highly intellectual activity. The Technology of today is based on theory with basic concepts and principles forming the knowledge base. It is interdisciplinary in nature and provides a unifying structure linking, in a meaningful way, most of man's activities. Yet, education has ignored, except from an occupational, career or vocational frame of reference, the study of Technology in our schools. We thus deprive our children of the knowledge and insights necessary to function effectively in a society composed of complex interrelated systems.

TECHNOLOGY AND EDUCATION

Access to tools: Technology has become, almost without our awareness, an all pervasive factor in the affairs of man. We have gradually become aware that the technology of earlier eras of civilization was entirely different from the phenomenon of today, both in the tools and the social consequences of the use of the tools.

Today man lives in and is continually exposed to the Technological environment. Yet, many lack a true understanding and comprehension of this environment. Some even take pride in not knowing about Technology. They treat Technology as if it were an object, something to be handled and manipulated as the early craftsmen handled and shaped a piece of wood or metal. As a consequence, Koestler maintains, they "utilize the products of technology in a purely possessive, exploitive manner without comprehension or feeling." In the process, Technology has become alien to man and he has been alienated by it. Man has no control over his life in this strange environment because he does not know what the system is.

At the same time we maintain the myth of a democratic Technology at a time when the consequences of choices by each and every citizen become more and more critical. We encourage individual participation without providing the knowledge or tools to make intelligent contributions. We make social decisions in the use of Technology without adequate information. We follow procedures used when Technology was less powerful and the consequences less final.

If we believe that man is best served when he is free and that participatory democracy is the best form of government, then man must participate in decisions concerned with the use of Technology. We must, therefore, develop a participatory Technology as well as a participatory democracy. One with out the other will not work. Participatory Technology presupposes freedom and responsibility as dones participatory democracy. It also presupposes knowledge and tools. The equation incorporates freedom to act and the knowledge and tools with which to act. These are the preconditions, it seems, if man is to again become part of the process with a sense of intelligent participation and not alienation.

If we believe that we, as citizens, should participate in determining the future of society, then we must educate ourselves to do so. The system is too complex, interrelated and interdependent not to do so. The phenomena of Technology demands major alterations in our system of education. The issue is critical. For instance, the characteristics of the Technological Society alter the equation with respect to error and failure. Failure in a complex modern society is of far greater consequence than in earlier societies.

In earlier times the Technology was not as powerful, dependency on multiple subsystems not as great. If a system was disturbed, it returned to equilibrium in a relatively short period of time. Today, this is not true. Those who recall the Northeast Power Failure can readily comprehend Branscomb when he says:

> ...our very survival becomes dependent on the absence of failure in the major sub-systems on which society depends. Among them are power, communication, transport, health services, food and peace keeping. (Branscomb, p. 974)

Although Technology has been one of man's main modes of expression, today great masses of people are denied access to its tools. The tools of Technology have become the property of experts and are under their control. Thus, the sophisticated tools and the knowledge of how to use the tools have become a commodity, bought and sold on the market place to the highest bidder, placing the control of society in the hands of a select few and alienating the remainder because of the unresponsiveness of the tools and the system to their needs and desires. We thus identify one of the most, if not the most, critical issue of education in a Technological society. Man cannot participate in the management and control of that which he does not know about or understand.

Modern Technology and its sophisticated tools and knowledge base require comprehension and understanding beyond the common sense and folk knowledge of yesterday. _If_ the system is to be responsive to man as were the tools and techniques of earlier times, _then_ an effort must be directed to the study of Technology as a phenomenon in the affairs of man, both from a technical standpoint and from a social-cultural perspective.

Many will challenge this point of view. They will maintain that man does understand his Technology. What those with this point of view fail to realize is that Technology has been created by some men, not all men. They also fail to realize that the creators of a given technique may not and probably do not comprehend the consequences of the introduction of the technique into society. The men who created and developed specific technologies do comprehend and understand the physical forces and principles which provide sterophonic sound, linear induction motors and color photography. They know and understand and can control these devices. But the issue is not the control of a single device; the issue is the understanding and control of the behavior of Technology as a system, as a major force of change and disruption within our society.

It is not only the question of how a device works technically. It is not only the study and comprehension of the behavior of the technical elements. It is the study and comprehension of the behavior of the social/cultural effects within the total system as well. In essence, it is the solution of the Man-Society-Technology equation. It is the study of the <u>behavioral characteristics of technological systems</u>. The concern is with the dynamics. It is not a concern with what a thing <u>is.</u> It is a concern with what the thing <u>does</u> within the system. It is an attempt to gain knowledge, to gain control, and thereby attain mastery over the tools of Technology for man.

Educational institutions have, for the most part, rejected the study and investigation of one of man's most creative intellectual endeavors, Technology. Most educational programs are patterned after the mass production factory of the era of the industrial revolution, turning out standardized products within a highly structured, authoritarian environment staffed largely by teachers unaware of the nature of our culture.

Over the years, the evolving Technology, with a new and expanding knowledge base, has transcended most educational efforts and the competence of the average citizen. Although we study politics, poetry and philosophy for the purpose of understanding our culture and ourselves, for some reason, we reject the study of that phenomenon within our culture which is a prime force in shaping our social milieu.

Many, if not most, educators treat Technology as something apart from the daily affairs of man. By doing so they turn the control of a powerful tool over to a regime of experts. They deny their students access to the very knowledge and tools so vital to creating, managing, regulating and directing Technology for their benefit as well as others. They visualize Technology as an "object" and not a "subject", as something "out there" not really important to education for life and living and thus inappropriate for study. It seems that educators are not aware of Technology, let alone engaged in the study of it. They insist on the study of the behavior of plants, animals, molecules and the history of man politically but not Technology. Technology seems to be an abstract man has created which exists outside the sphere of the awareness of educators.

The educational system has muted man's awareness of his ignorance of Technology and pursued the policy of machine tooling him into a marketable commodity in a narrow speciality. In the process an "urban barbarian" (Koestler) has been created by an educational system which has denied him access to knowledge and tools, muted his interest and awareness and placed him in the position of being effectively shaped and controlled by those in command of the tools and knowledge of the new Technologies. Technology has become less and less responsive to the needs of the common man and his society. The common is a part of the enterprise but not a participant.

Our educational system has acquiesced. No longer does the system focus on the education of man to free him. The emphasis is on training man in and for the system. A case in point is the present emphasis on job and career-centered education. This emphasis causes freedom to take on a hollow ring and education to lose meaning.

Our values have, it seems, equated education with jobs and careers. One's life is measured in terms of one's job and in the process becomes less and less rewarding. The focus is on one goal, the economic goal. Education has become linked to the market place. In the process man becomes a marketable commodity. And his environment becomes a marketable resource. The result is the inevitable destruction of both as the record clearly shows.

Many educators seem to be accepting the mentality of the proponents of occupational, vocational and career education and their perception of man as a worker, of society as a workshop, and life as work. Not only is the meaning of man and his life restricted by these proponents but they have begun to restrict the definition of work, a very honorable term until educators began to define it for their restricted purposes.

Career education is a major misdirection of the economic and human resources of our country at a time when the issues are other than careers - when the issues are other than jobs *per se*. The issue is the determination of the kind of society best suited for all men, a society concerned with the full human development of all men. Today, the potential exists to create the most humane existence, the highest order of life ever, for more people than ever before, if we but focus on the education of man as a human being and not on the education of man for work or a career. The highest order of human existence for the most people will come about through a high level Technological society provided man focuses his attention on understanding and controlling for his benefit the Technology he has created.

This means that education, if it is to serve man in gaining an understanding of life and living in a Technological society, must not be *a part* of the work world but must be *apart* from it. Education must direct attention to providing man the necessary perspective and ability to engage in critical analysis of the system, a vital element in making value judgments about the man, society, technology equation.

The issue seems to be one for which education has not developed successful alternatives. Most educational programs have focused on the past, the here and now and on meeting rather specific vocational needs. The problem, however, is one of preparing people to engage the question of determining meaningful social policies for the future. It involves, as Brzezinski states: "the explicit definition of social purpose." (p. 309) What is being asked is that man engage in questioning that which he has taken as a given, the future of man and society. This requires a new mentality, a different way of perceiving. It requires that all men involved in determining the questions and their answers have knowledge and tools adequate to the task. It means a comprehension of the concept of system and the understanding that everything affects everything else. The new mentality requires a comprehension of problems and issues in terms of systems, interactions and interrelations. The goal of education should be to provide individuals with the means to find order in a complex universe and to attain the knowledge, skills, tools, attitudes and values required to participate successfully in the future.

Without access to tools and without knowledge, man effectively loses control of his Technology. And the institution of education, through its restricted vision of reality, perpetuates the system of ignorance through its pride in not being involved with Technology and the new reality. The Education system thus creates and continues to develop citizens entirely dependent on science and technology, but ignorant of both. The system produces, as Koestler notes, men who lead the life of urban barbarians, totally ignorant of the culture which supports them.

The low level of awareness and interest in Technology, coupled by indications of resignation or alienation on the part of students and citizens, portends future social and political changes that may be irreversible.

Yet we find, as we study the Man, Society, Technology equation, that knowledge of social, psychological and Technological systems, together with access to tools and the know-how in their use, are absolutely essential if man is to control his environment, establish equilibrium and attain his full potential as a human. It is, therefore, absolutely essential that education in a Technological society provide access to tools and reality.

Technology can be a powerful tool for man if he is educated in the use of the language and the tools. The complexity of the problem is immense and can only be solved when man develops an awareness and comprehension of the behavior of social, psychological and Technological systems and their interrelationships. The goal becomes one of developing an awareness of the behavioral consequences of Technology through _if-then_ statements. In addition it must be remembered that the question is not only one of controlling Technology but one of man controlling his own actions as a critical element within the system. It is only by disciplining himself, as well as Technology, that man can become free.

Technology and Education

The Discipline Base: An analysis of the man, society, technology equation indicates that the entire base of society has changed and continues to change due to man's implementation of his innovations in industrialization, automation and cybernation. It has become evident that man, to function effectively today and tomorrow in a democratic society, must understand in depth the phenomenon of technology as a major force within society if he is to apply intelligently his accummulated wisdom to new conditions and a more humane future.

This will require citizens capable of engaging new problems, of learning new knowledge and of accepting change as a normal state. Learning must become a perpetual endeavor. This will require an educational structure emphasizing the intellectual processes of the disciplines of knowledge. In addition attention must be directed toward: (a) the identification of problems, (b) the development of tools for solving the problems, (c) the processes for engaging and solving the problems, and (d) a comprehension of the behavior of Technological and other systems. These are the essential elements. The focus is on man's cumulated knowledge and the processes of creating knowledge found in the established and developing disciplines. The focus on the disciplines of knowledge (the Sciences, the Humanities and the Technologies) is intentional and essential.

Until recent times the discipline of Technology has received little attention. For years men, eminent men, have been building the knowledge, developing the concepts and changing history without cognizance of many of the recognized scholars. Little was recorded of the eminence of the discipline. Most of its developments occurred between events generally given greater recognition by historians such as wars, uprisings, revolutions, governmental changes and other political events.

It was between these events, however, that truly significant developments were taking place, developments which changed the world such as: the magnetic compass, papermaking, printing, gunpowder, the wheel, irrigation and water Supply systems, sanitation, electricity, the clock, gears, pulleys, water wheels, telescope, microscope, steam engine, ships, bridges, the internal combustion engine, telegraph, telephone, radio, television, atomic energy and the computer. The Technological revolution was a quiet revolution and continues today with significant consequences to man. Today, as in the past, man's creations in Technology are forcing a reevaluation of his basic concepts and even his way of thinking.

The silent revolution created by man through the application of his intellect to environmental problems has been facilitated by his realization of the significance of theory. Man has discovered that theory is a tool to be used to reach new goals or to explore new concepts. He has also discovered that theories must be discarded when they fail to provide progress or direction in the solution of problems. This recognition has changed man intellectually, He has cast aside creeds, narrow definitions, matters of opinion and dogma as unsatisfactory, since they close the circle of consideration and do not facilitate the development of his primary resource, Technology.

Technology, of course, has not been created or developed by <u>all</u> men. It has been created and developed as a dynamic and vital force by some men who did not accept known answers as absolute or as fixed entities. These men accepted technology as a vital resource necessary for survival and addressed themselves to the solution of questions and problems of cardinal significance. In doing so technology has emerged as an intellectual discipline, significant in its own right.

We discover, upon examination of selected criteria for a discipline (Shermis), that Technology:

I. <u>Has a Recognizable and Significant Tradition; an Identifiable History</u>.

Man's whole civilization is based upon his Technology. Without it man, an almost defenseless creature, could not have survived and progressed. From the dawn of civilization man has developed his Technology to master his environment. The potential of Technology challenged him, and we find his technological history recorded in such works of literature as <u>Man the Maker</u> by Forbes, <u>History of Technology</u> by Singer and others and <u>History of American Technology</u> by Oliver.

II. <u>Has An Organized Body of Knowledge</u>.

Today the body of knowledge in the technologies has reached a true universalism. It has permeated our industrial way of life to the extent that there is a universal sharing of like points of view, like disciplines, like reference to objectively valid criteria and like modes of making judgments. The construction and layout of industrial plants, the utilization of transportation and communication networks, the operation and control of industrial processes, the analysis and solution of problems and even the training and preparation of the workforce are evidence of a universalism, of an organized and objectively determined body of knowledge.

The technical and conceptual tools necessary for dealing with the body of knowledge have been developed. The discipline of technology is of international proportions. Regardless of nationality, the body of knowledge is added to by men utilizing similar theories, similar concepts and similar technics to produce identical or complementary inferences, proofs, discoveries and developments.

III. Is Related to Man's Activities and Aspirations and Addresses Itself to the Solution of Significant Problems to Paramount Significance to Man and His Society.

Few other areas of endeavor by man are so intimately related to his activities and aspirations. Today wherever we look Technology is attracting overwhelming interests and commanding the attention of the people of all nations. Technology has become one of the indispensable keys to success in defense and war, to the realization of the hopes of the mass of people in under-developed countries and to the eventual success of the freedom of man and his democratic institutions. Diplomacy backed up by the newer technologies may well achieve what man has strived towards for centuries. It may well force man to live in peace, a goal of good men of all times.

IV. Has A Considerable Achievement in Both Eminent Men and Significant Ideas.

Meeting this criterion seems to be self evident. We need only mention a select few of the many hundreds who have made incalculable contributions to the field of Technology. Many names are omitted from the record because the contributions were made prior to recorded history or were considered to be of little consequence at the time.

For the record we can cite men such as Gutenberg, Mergenthaler, Watt, Fulton, Whitney, Bessemer, McCormick, Bell, Maudslay, Nasmyth, Wilkinson, Roberts, Wilkie, Edison, Steinmetz, Ford, Wright, and Goddard. These men contributed ideas and concepts relating to printing, power, production, communications, machine processes, electrical theory, transportation and aerospace.

V. Provides Stimulation and Inspiration for Man to Further His Ideals and to Reach Goals.

During a recent stage in his Technological development man made a profound discovery, and in so doing changed himself intellectually. No longer did he ask whether a problem can be solved or not. His only question was how long it would take. Man faced the future with a positive mind. Through his application of scientific and technological theories to the satisfaction of human, new frontiers for the betterment of all mankind have been opened. From the dawn of the steam age man has advanced steadily into new worlds; worlds of electricity, the internal combustion engine, powered flight, communications, transportation, research, production, construction, electronics and recently atomic power and cybernation.

Man has been stimulated and inspired by Technology and looks forward to the new worlds of the future.

Upon examination, we discover that the disciplines of knowledge are not merely collections of information, they are conceptual models which men have constructed to give meaning to experience. The disciplines stress the unity of knowledge rather than fragmentation into highly specialized compartments. The comprehension of systems and the relationships between Technology and other bodies of knowledge is essential and must be taught because the problems of today and tomorrow require a multidiscipline approach for solution.

The youth of today are entering a society best described as a constantly changing Technological society with increasing abstraction and symbolism. Each one must be educated to the utmost of his ability if he is to participate in a knowledgeable way, not as a manipulator of technique, but as a functioning intelligent citizen in a changing society. To meet this need, the best and most efficient approach is through the study of the disciplines of knowledge including the Sciences, the Humanities and the Technologies.

Technology and Education

Structure and Content: Those concerned with the development of educational programs and curriculum development in fields of study which derive their content from the technologies discover the task is becoming increasingly difficult. No sooner has a curriculum been developed then it becomes out of date because of the continuing advance of technology. The continual development of

Technology has resulted in an increasing tendency toward educational specialization with the resulting loss of communication among practitioners in education attempting to derive meaningful curricula. This occurs at a time when the growing complexity of Technology and education requires the cooperation of larger groups or teams composed of multifarious specialists on a regional, national or even international basis.

Experience indicates, however, that when teachers in the technologies meet to consider curriculum problems, they lack a common frame of reference with respect to content and knowledge structure. Most teachers recognized that some change is necessary. How to proceed is the problem. Lacking is a common base established upon agreed and verifiable principles. What is needed is a discipline base with common terminology relating to content selection and the development of an overall scheme or matrix.

A review of the literature outside the field of education indicates the problem of massive amounts of new data and information is being solved by systems analysis, one of the first stages of which is the ordering of the field of study through some classification or taxonometric procedure. Curriculum analysis and development efforts have been less than rewarding when conducted without an agreed upon discipline with an agreed upon taxonomy of the knowledge base identifying the structure and its elements. The question of "what to teach?" is basic in order to establish the content universe as a base for the derivation of concepts, principles, and processes of the discipline or knowledge area.

The question of "what to teach?" is particularly valid for those concerned with general education, industrial arts and Technology. General education is concerned with common learnings based upon cultural universals. Those in the field of industrial arts and Technology, therefore, are concerned with universal Technological endeavors, together with the central themes and disciplined understanding, as distinct from concern with specialities which consist principally of vocational callings. Further, general education and the industrial arts are concerned not only with perpetuating what others have created or developed (what is), but also the development of individuals capable of discovering new concepts and of functioning in the processes of the disciplines and their unique ways of knowing, doing, acting and thinking.

One primary reason cited for all taxonometric efforts is that these efforts provide an accurate perspective of the content reservoir. The purpose of a taxonomy is not to limit a field of knowledge or discipline but to ascertain the totality of the system together with the component elements and the interrelationships. Without an accurate perspective of the whole, further work in the identification of concepts, principles, processes, models and systems cannot proceed. Curriculum development thus follows the determination of structure and its elements.

Kuhn (p. 32) notes that during the history of a given discipline several systems of classification may be offered and that after trying them, the practitioners usually settle on a single system of classification. Evidence indicates that various areas of the technologies are reaching a stage where fruitful efforts in classification can take place. More and more what was once divided into separate categories, with separate functions and purposes, is being considered in terms of systems such as: Communication Systems, Transportation Systems, or Production Systems. Concern is being directed to the "whole" and not only the component parts. Thus, the concern of the industrial arts with universal technological endeavors and central themes aids in conceptualization. For instance, the function of the knowledge area of communication concerns information dissemination, storage, retrieval and use. The methods of accomplishing this, whether in a man to man, man to machine or machine to machine system, vary with the communication problem.

Elements of radiant energy, printing, photography or graphic representation by man or machine are utilized to attain the most valid solution to a given communication problem. The search is for unifying themes. In this search knowledge classifications aid in the discovery of the themes and the interrelationships among various disciplines. New insights are attained about the knowledge, technology, society equation.

In the physical technologies, from which the industrial arts derive content, the elements in Figure I provide insight into the concept of Technology as a discipline. The model has several characteristics which should be noted.

First, two continuums of emphasis in the discipline of Technology are provided which relate to (1) the environment and (2) man's activities. The <u>environmental continuum</u> ranges from natural to artificial, thereby stressing the relationships between man, society and Technology. Man's technological activities are carried out in the areas of Production, Communication and Transportation. These technological activities can be defined by their functions as shown in the following outline:

TECHNOLOGICAL ACTIVITY	FUNCTION
1. Production (Manufacturing, Construction, Processing)	Provides goods and services of economic value for man's needs and wants.
2. Communication	Provides for information dissemination, storage, retrieval and use.
3. Transportation	Provides movement of man, materials, products and services.

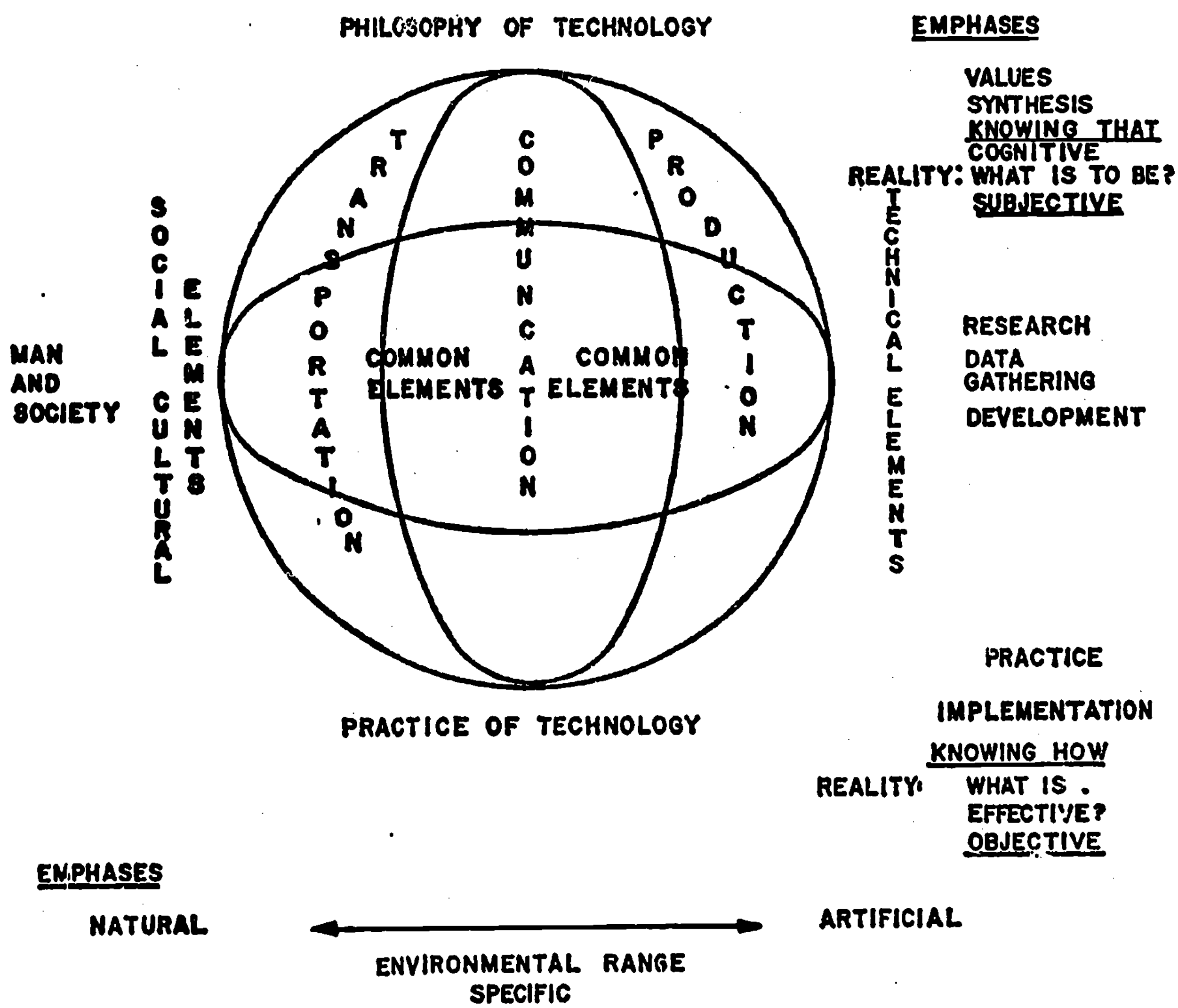
The activity continuum ranges from practice or application to philosophy and describes the types of endeavors engaged in by man as he pursues technological problems. The sphere acknowledges functional relationships among the technologies. These are indicated through common elements and with other disciplines. A base is thus established for the analysis of the Behavioral Characteristics of Technology.

The analysis of systems of knowledge provides also a base for understanding functions and relations. Thus, instead of increasing the number of parts, simplification evolves through the discovery of interrelated knowledge and overall inclusive concepts.

The present effort provides an example of ordering one of the fields of technology, namely, Transportation Technology, an endeavor identifiable in all cultures.

FIGURE I

SPHERE OF UNIVERSAL TECHNOLOGICAL ENDEAVORS
THE PHYSICAL TECHNOLOGIES



> Transportation can be described as that activity of man concerned with the movement of himself, his goods or services from some point A in a given environment to another point B in the same or alternate environment by some technical means.

<u>Taxonomies: Guidelines and Principles</u>

There are numerous ways of classifying things. All schemes of unification depend on how one looks at his universe. Maruyama's (p. 55) analysis identifies three organizational universes, (1) the classificational, (2) the relational and (3) the relevantial. Each scheme depends upon how one views his universe. Some meet the needs better than others, depending upon basic assumptions.

The present effort is a classificational one based upon the assumption that the industrial arts are concerned with disciplined knowledge in the technologies which includes concepts, principles and processes developed by practitioners engaged in authentic disciplined understanding of the phenomenon of Technology.

It is, therefore, a study of a man-made real system. In this case it is a study of transportation and is directed toward the identification of the knowledge structure and activities characterizing the sub-discipline area of transportation. The knowledge structure approach is supported for several reasons. (Bloom, p 32-36)

1. Knowledge is basic to the education of an individual. It acquaints him with the field of study and what is real.

2. Knowledge is basic to all other ends and purposes of education. Concepts and principles are based on knowledge of some of the realities.

3. The attainment of the knowledge of a field is fundamental to learning the intellectual processes and methodology of the field. It is necessary for attacking problems of the field.

4. Interests, attitudes and appreciations have their base in the attainment of knowledge or information of the discipline field.

A taxonomy of the knowledge field of transportation technology is a useful tool and for several reasons. It orders the field of knowledge, thereby enhancing the concept that <u>knowledge which is organized and related is better learned and retained than knowledge which is specific and isolated</u>. It also provides a means of identifying functional inter and intra relationships and therefore enhances learning and understanding of phenomena specific to the area of knowledge and related to other knowledge areas. As a tool, its purpose is not to limit a field of knowledge arbitrarily but to ascertain its totality together with the component elements and their interrelationships.

In addition, certain other values accrue according to Krathwohl and others. These relate directly to specific problems in education. A taxonomy aids in:

(1) clarifying and "tightening" the language in curriculum efforts and improves communication, (2) equalizing evaluation standards by increasing the compatibility between programs in different geographic areas, (3) providing comparative educational standards for studying educational programs, (4) providing for adaptability to change by identifying in the structure future technological developments, (5) stimulating research efforts by aiding research workers in formulating hypotheses about content selection, learning levels and the attainment of goals and performance criterion, (6) economizing effort by providing curriculum workers with the total range of content potential available, together with a common set of definitions and a common language and finally (7) the identification of curricular voids by identifying areas of neglected curriculum research with the establishment of a comprehensive content reservoir.

A number of criteria have been established as guides in the development of taxonomies. Most studies cite the requirement of universalism. Applied to the present effort, this requires that the taxonometric structure for transportation must be applicable to transportation technology in general and not indigenous to any one country or civilization. In addition, the purpose and function of the classification system must be identified. The purpose of the present system is to provide a base from which to identify content for the study of transportation in the area of industrial arts and Technology as a part of general education. Therefore, it is recognized that other schemes of unification exists, but for other purposes.

Kuhn (p. 32) proposes that classification systems best suited to specific requirements should:

1. contain the largest amount of information for the purpose specified,

2. provide the most efficient system for handling the kinds of information the practitioners require, and

3. permit the largest amount of information to be deduced from a given amount of other information.

Other criteria, developed by Maruyama (p. 56-57), indicate that a taxonometric analysis should evidence: (1) mutually exclusive groups so that members within groups are indistinguishable or equivalent, (2) objectivity based upon given criteria and (3) a hierarchy of categories from the <u>general</u> to the <u>specific</u>.

It is possible to identify other criteria for the evaluation of taxonometric structures in addition to the above by analyzing various classification schemes. For instance, each category is identified by a word or phrase which delimits the category but is non-transient and permits additions to the structure as discoveries of new knowledge warrant. There are generally a relatively small number of mutually exclusive groups or categories. The distinction between groups or categories is established by a universal concept inherent in the knowledge area itself. Taxonomies are internally consistent and have structure because internal relations exist among the elements. The structure is dependent upon these relationships.

A Taxonomy of Transportation

It should be recognized that the present effort is an analysis of a man-made system. Ordinarily, an analysis of a system and subsequent model development occurs when there is a desire to understand the system better. To understand man's efforts in the development of transportation, it is necessary to obtain an historical and contemporary perspective. An historical analysis indicates that the three major determiners of Technology, throughout the history of man, have been: (1) the area of production including tools, power, work skills and materials, (2) the area of transportation and (3) the area of communication. An analysis of transportation reveals that several mutually exclusive but interrelated systems have been a consistent part of transportation development regardless of the level of sophistication or type of transportation involved. Furthermore, the study of this phenomena of technology, as with other areas of technology, is environmentally related but in a different way. All transportation problems are related to terrestrial, marine, atmospheric or space environments.

The study of the development of civilization and man's efforts in Technology show a definite relationship between man's technology and his societies and cultures - the social-cultural elements. These interrelationships must be recognized and are identified in the present analysis as a part of the goal of a total matrix shown in Figure II.

The matrix in Figure II identifies the basic systems of transportation as well as the voids requiring attention. The first effort concerns the knowledge taxonomy which is basic and essential to other developments. Figure III illustrates an organization scheme relating the field of transportation to other areas of technology. The discipline is identified as Technology and the basic elements as technical and social-cultural. The general areas of Technology are Production, Transportation and Communication previously identified. The environmental divisions of transportation are categorized as terrestrial, marine, atmospheric and space.

Figure IV identifies the systems fundamental to all types of transportation regardless of environmental area, culture or level of sophistication. Each system can be defined specifically and described functionally. For instance, control can be defined as: the actual mechanical procedures used to steer a vehicle along a path, or to maintain its attitude in a specific orientation in space. Guidance can be defined as: the information required by a vehicle to make it follow a prescribed path or fulfill a particular objective.

Each system can be defined more specifically by identifying categories and types. Figure V identifies three categories of the propulsion system plus several types of power or energy.

An analysis of propulsion shows that not only are there categories and types but also classes and orders as shown in Figures VI and VII. It is possible then to move hierarchically in an analysis of propulsion from the identification of the order (reciprocating expansible chamber), to the class (internal conversion), to the type (thermal), to the category (power), to the system (propulsion), to the environmental division (terrestrial).

Similar classifications can be determined for the systems control and guidance as shown in Figures VIII, IX and X. Control, as it relates to transportation, involves a static or dynamic situation and utilizes some force to change, alter or regulate the velocity, direction or attitude of a vehicle within a given environment. For instance, a tube type vehicle, which has one degree of freedom (moves in one direction in one plane only),(Ross p. 27) can be controlled in terms of velocity by altering pressure (type of control) through pneumatic means (class of control) by actuating, arresting or stablizing directly, remotely or automatically (order of control). Or a vehicle, designed for use in an atmospheric environment, can be controlled directionally aerodynamically by means of surface alteration mechanically either directly, remotely or automatically.

Whereas control relates to change, guidance involves consideration for stability which is concerned with following a prescribed path or fulfilling a particular objective. Therefore, guidance is equated with information and interrelates with control by providing information for actuating, arresting or regulating the velocity, direction or attitude of a vehicle within a given environment. Guidance systems can be categorized three ways depending upon the type of transportation device and the environment. (Ross p. 27) These are expressed in degree of freedom and describe the directional flexibility of a vehicle. The greater the degree of freedom, the more complex the guidance problem. A tube type vehicle has one-degree of freedom and can move in one plane in one direction. An automobile has two degrees of freedom and can move in one plane in two directions. A submarine or space vehicle can move in two planes and in three directions.

The type of guidance system is some form of man-machine configuration which relates to a class describing a guidance function. The order describes the means of sensing, transmitting, displaying or storing information. It is then possible to analyze a guidance system for an automobile as involving the order (optical or accoustical), of the class (sensing), of the type (man to machine), of the category (two degrees of freedom). Each of the elements in the classification hierarchy can be further subdivided into those sub-elements already known, accommodate new elements or predict probable future elements.

Similar analyses can be made of the suspension and support systems. Suspension concerns the question of the means of suspending a vehicle in or on a given environment and would consist of categories such as: airfoil, hydrofoil, surface effect, wheels, lubricant, magnetic and gravity. The support system would consist of categories related to life support, operations support, legal support, economic support and maintenance support.

It should be noted that not only do specific interrelationships exist within and between the several systems of transportation but also in a number of specific ways between transportation and communication technology and certain sciences. Knowledge development in communication electronics aids directly the development, improvement and understanding of guidance systems. Information theory in the field of communications, such as computers, provides a base for the development of fully automatic transportation systems. Geography, meteorology and astronomy provide knowledge and information about the several transportation environments so vital in the solution of problems related to vehicular design, including propulsion, structure, guidance, control, supervision and support systems.

FIGURE II

TRANSPORTATION
DISCIPLINE STRUCTURE AND CONTENT

	DISCIPLINE STRUCTURE					
SYSTEMS	KNOWLEDGE STRUCTURE (TAXONOMY)	CONCEPT TAXONOMY	PRINCIPLE TAXONOMY	PROCESS TAXONOMY	FUNCTIONAL RELATIONS	SOCIAL-CULTURAL ELEMENTS
PROPULSION						
STRUCTURE						
GUIDANCE						
CONTROL						
SUSPENSION						
SUPPORT						

FIGURE III

TRANSPORTATION TECHNOLOGY
ENVIRONMENTAL DIVISIONS

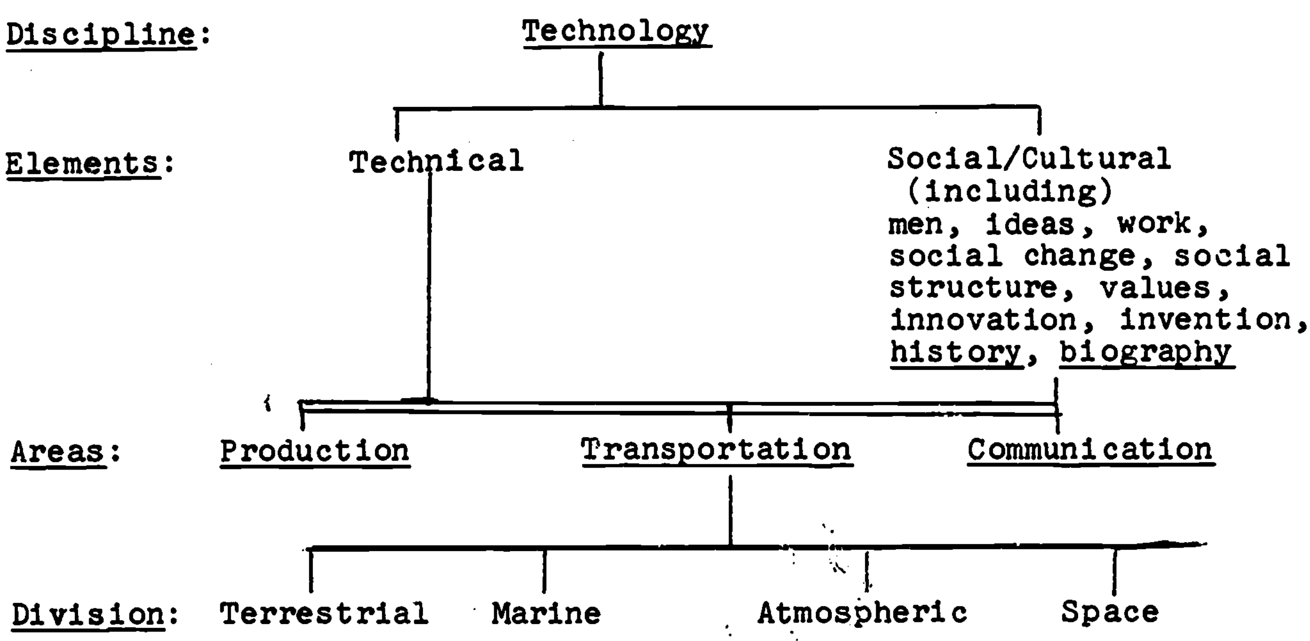


FIGURE IV

TRANSPORTATION TECHNOLOGY SYSTEMS

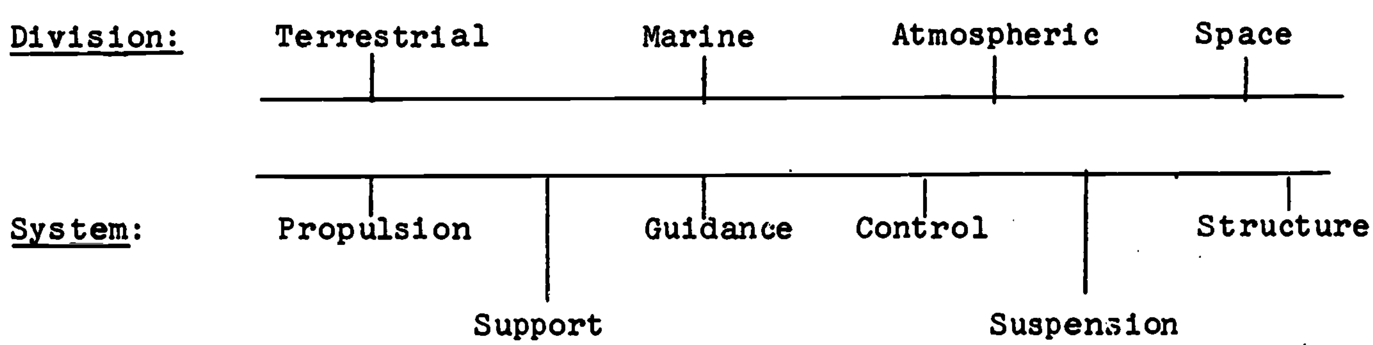


FIGURE V

TRANSPORTATION TECHNOLOGY CATEGORIES AND TYPES

System: Propulsion

Category: Power, Transmission, Drive

Type: Human, Animal, Thermal, Nuclear, Chemical, Mechanical, Electrical, Solar, Magnetic, Gravity

Electrical: Electrothermal, Electrostatic, Electrochemical

FIGURE VI

TRANSPORTATION TECHNOLOGY CLASSES AND ORDERS

System: Propulsion

Category: Power

Type: Thermal

Class: Internal Conversion, External Conversion, Direct Conversion

Order: Expansible Chamber, Reaction, Linear

Expansible Chamber: Reciprocating, Rotary

FIGURE VII

TRANSPORTATION TECHNOLOGY
TAXONOMY SUMMARY

Discipline:	Technology
Element:	Technical
Area:	Transportation
Division:	Terrestrial
System:	Propulsion
Category:	Power
Type:	Thermal
Class:	Internal Conversion
Order:	Expansible Chamber - Reciprocating

FIGURE VIII

TRANSPORTATION TECHNOLOGY
CONTROL SYSTEMS (VELOCITY)

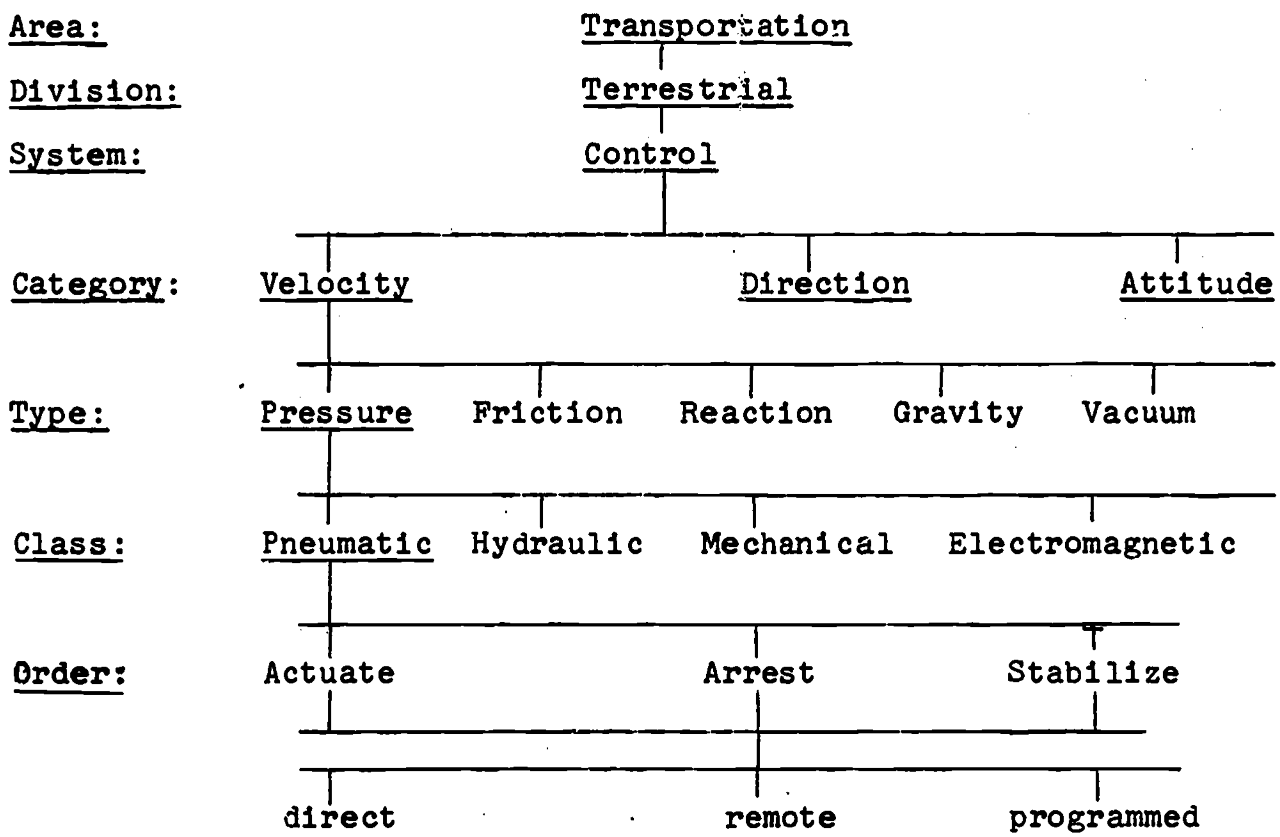


FIGURE IX

TRANSPORTATION TECHNOLOGY
CONTROL SYSTEMS (DIRECTION)

Area: Transportation

Division: Terrestrial

System: Control

Category: Direction

Type: Aerodynamic — Hydrodynamic — Gravity — Friction

Class: Surface Alteration — Power Alteration — Axis Alteration

Order: Mechanical — Pneumatic — Hydraulic — Reaction — Electrical — Chemical

direct — remote — programmed

FIGURE X

TRANSPORTATION TECHNOLOGY
GUIDANCE SYSTEMS

AREA: TRANSPORTATION

DIVISION: TERRESTRIAL

SYSTEM: GUIDANCE

CATEGORY: One-degree of freedom | Two-degrees of freedom | Three-degrees of freedom

TYPE: Man to Man | Man to Machine | Machine to Man | Machine to Machine

CLASS: Sensing | Encoding | Transmitting | Signalling | Receiving | Decoding | Displaying | Storing | Retrieving

ORDER: Mechanical | Graphical | Radiant | Thermal | Electrical | Acoustic | Chemical | Optical

FIGURE XI

TRANSPORTATION TECHNOLOGY
INTERDISCIPLINARY RELATIONS

Communication Technology		Transportation Technology Terrestrial Space Marine Atmospheric	Natural Science
Communication Graphics (Photography)	S	Propulsion	Geography
	Y	Guidance	Meteorology
	S	Control	
Communication Electronics (Navigation Radio Radar)	T	Structure	Astronomy
	E	Support	
	M	Suspension	
Information Systems (Computers	S		

TECHNOLOGY AND EDUCATION

Content and Method:

Closely related to the identification of the discipline and knowledge base for the industrial arts is the need to identify the concepts, principles, processes and functional inter and intra relations of the discipline. The processes of a discipline have a distinct function in the teaching-learning situation inasmuch as they identify what the practitioners of a discipline actually do as they pursue their discipline. The nature of the discipline, therefore, provides direction for curriculum design which is concerned with four interrelated questions. What to teach and Why? Who to teach it to and Why? When to teach it and Why? How to teach it and Why?

A critical analysis of the discipline of Technology shows that this creative endeavor of man places an emphasis on man, his human attainments and problems and his technical attainments and problems. A study of the structure of Technology identifies certain basic tenets which aid in answering questions pertaining to teaching methodology and learning environment. Technology is: activity centered, problem centered, environmentally centered and future oriented. The central question of technology is: What is to be? Therefore, the learning environment should be modeled to enhance these tenets and to engage the question: What is to be?

Parallel and essential to the development of the content base, which identifies the structure of the discipline and the areas of man's creative technical endeavors, is the identification of the intellectual processes of the discipline; the modes of thinking, performing and ways of securing, evaluating and using data and information to cumulate knowledge in the advance of the discipline. It is essential that these elements be identified in order to develop further comprehension of the Behavior of Technological Systems as well as an understanding of the behavior of the practitioners of the discipline. The latter provides those in education with a basis for determining the behavioral characteristics of learners engaged in the study of the discipline.

Diagramatically the procedure develops as shown in Figure XII. There are essentially nine major steps to program development utilizing the discipline and taxonometric approach.

1. Establishment of the content reservoir-taxonomy.
2. Identification of the basic principles and concepts of the discipline from the content reservoir, including technical and social/cultural elements.
3. Identify and develop principle and concept statements describing each principle and concept determined in step 2.
4. Identify and establish the processes of the discipline (modes of thinking, performing and ways of securing, evaluating and using data and information to cumulate knowledge in the advance of the discipline) related to each principle and concept.

5. Identify and establish behavioral objectives associated with each principle and concept.

6. Establish performance criteria for each behavioral objective.

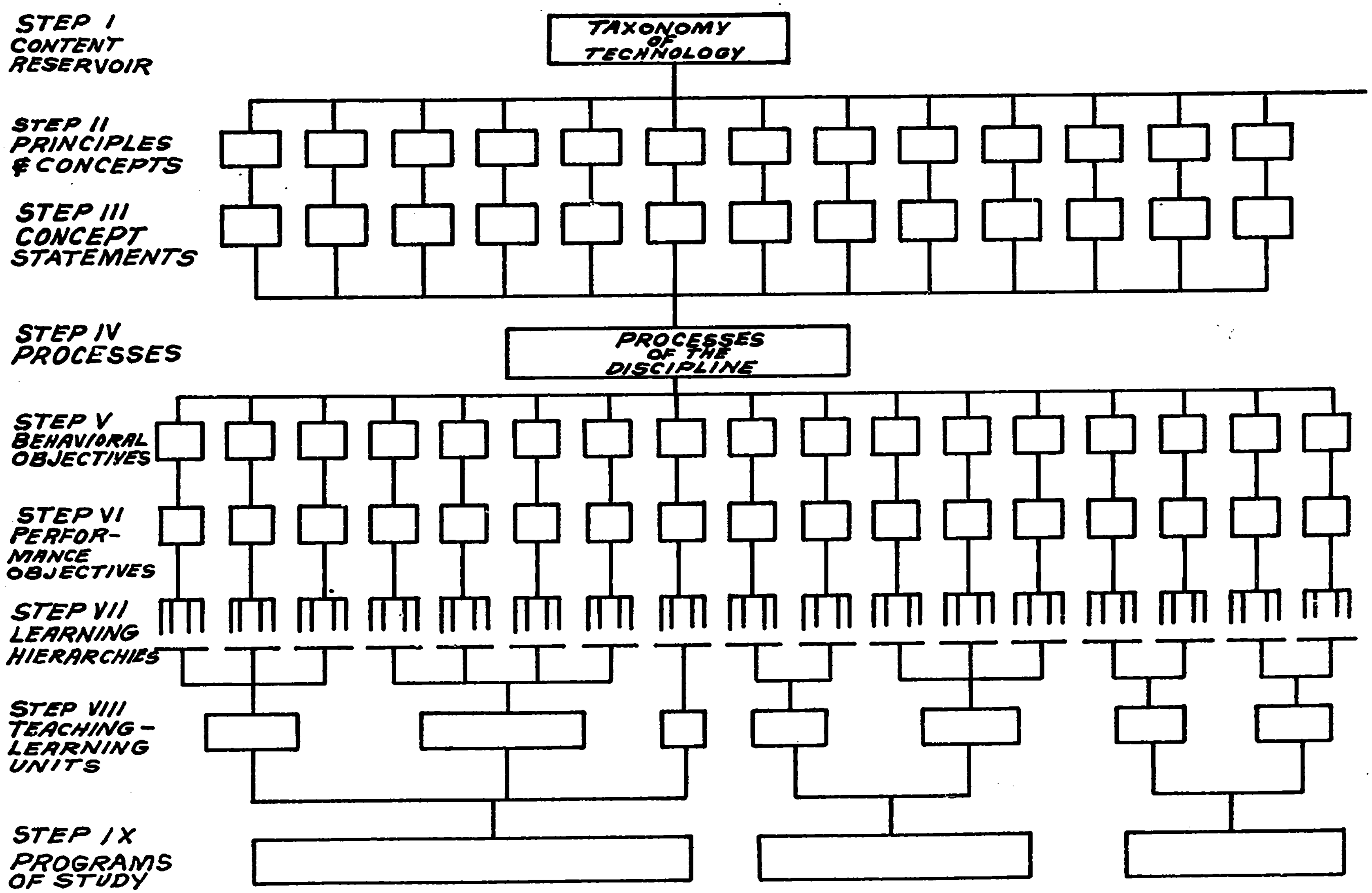
7. Develop learning hierarchies for each sub-concept for each level of instruction. (The nature of the learner and the nature of the processes of the discipline are related at this point).

8. Identify and establish teaching-learning units utilizing information from steps 3 through 7.

9. Establish programs of study through the grouping of logical combinations of teaching-learning units.

Combining a knowledge of the true nature of the discipline (gained through efforts in taxonometric analysis of the content and processes of the discipline) with a knowledge and understanding of proven practices related to the learner should provide for a combination of content and teaching methodology evidencing a realistic and relevant whole rather than false dichotomies. By the same token, it should become possible to again assert that industrial arts and Technology are a part of general education since the emphasis would be on the nature and strategy of inquiry. Programs of study would be problem oriented. The emphasis would be on the modes of inquiry and ways of thinking in the discipline which provide the base for continual learning and adaptability for change. It is possible, therefore, by utilizing the discipline approach to the study of Technology to identify not only the behavioral characteristics of the discipline and its practitioners but to determine the behavioral and performance expectations of the learner.

FIGURE XII



— PROGRAM DEVELOPMENT MATRIX —

<u>Choosing a Future</u>: Technology has always provided man with new choices and more options. Throughout man's history he has increased his potential for more freedom through his creation of Technology. As man became free of the restraints of the environment, he enhanced his potential for creating a true Technology. At the same time, man through his Technology, has created new tools, methods and procedures which enhance his ability to choose from the options created by his endeavors in the technologies.

The question of choice today, however, is becoming more critical. Increasingly the consequences of the choice of options are becoming more final.

There are many options associated with the phenomenon of Technology and the institution of education. The options, however, involve philosophical questions as well as technical. The choices concern values and direction and can be arranged on a continuum and developed into a series of <u>if</u>-<u>then</u> statements dependent on choices made.

When this is done, the issue is greatly simplified. The question becomes one of control, the control of the behavior of the system in attaining equilibrium rather than immobility and regression or disruption and ultimate destruction.

The criterion for judgment is man and his role in the system. If we can locate our choice on a continuum of choice for man ranging from less freedom, less participation and fewer options, to more freedom, more participation and more options, then we can determine the answer to questions such as:

1. the degree of socialization and control of tools,
2. the degree of socialization and control of knowledge and know-how,
3. the character and behavior of educational systems, and
4. the character and behavior of Technological systems.

The character and nature of education and Technology are thus a function of choice.

If we choose answers which direct our energies toward more freedom, more participation and more options, then it is imperative that education, at all levels in a Technological society, (1) incorporate the study of the Behavior of Technological and Social Systems, and (2) provide access to the tools and aid all citizens in obtaining the knowledge and know-how necessary to pursue the goals to the level required for the system to function most effectively. These are basic requirements if man is to attain the most humane existence ever and enter a future determined by choice and not by chance.

Regardless of the position we choose on the continuum of choice, it is essential, if education as an institution is to meet the needs of citizens in a high Technology society, that its stance be altered and rather than directing attention to the past and what was, or to the present and what is, that the focus change to the future and what is to be.

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